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Abstract

DESIGN OF CONTROL SYSTEMS FOR GAS-COOLED REACTORS

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The practical application of control principles to gas-cooled, graphite moderated reactors is discussed, with particular reference to the grouping, spatial distributions and movement rates of controlling absorbers. Both static and kinetic aspects of control are considered; some requirements can only be expressed qualitatively, and some are conflicting, necessitating compromise; adequate monitoring of reactor conditions is essential.

Speedy and economical design analysis methods are necessary to complement fully detailed analysis methods, which are more suitable for detailed operational studies of reactor behaviour. Typical design methods suitable for static and kinetic control analysis are described.

Various groupings of the coarse control rods for start-up are considered and it is shown that a four group scheme probably provides the best arrangement. The use of automatic spatial control rods for both unison and local control is described, the opposing demands affecting movement rates are discussed and an (x,y) alternative layout to the conventional sector scheme is introduced. The merits of fixed and moveable absorbers for power flattening are compared; the need to consider the spatial control and override rod groups as integral parts of the flattening and the importance of symmetry in the rod groups are emphasised.

The control principles discussed above are illustrated with reference to two contrasting systems. Firstly, the Tokai design is considered; this is a

relatively small reactor at an advanced stage of construction with many features common to other Stage 1 Magnox reactors. The design includes secondary shut-down devices using boron balls to give increased protection against earthquake hazards. The way in which these devices, as well as the control groups and variable flattening system, are accommodated within a single grid of standpipes is described, particular attention being given to eliminating the possibility of "local criticality". Typical spatial transient behaviour for the sector arrangement of controllers is illustrated and the effects of control thermocouple location relative to the rods are indicated.

Secondly a new core design is considered and the control system described; this core is much larger than that of the Tokai reactor and fixed flattening is utilised. Because of the large size it is possible to extend the integration of spatial control and override rods with the flattening; this improves both the core efficiency and the automatic flattening effect of the spatial control rods. The advantages of an (x,y) arrangement of spatial control and override rods for a large core are discussed. Results of radial-azimuthal stability studies and transients following local absorber movement are given.

The likely trends in control systems for future reactors, such as the advanced gas-cooled reactor, are discussed, and include closer integration with conventional plant, better load following, and increasingly flexible operation.